

MICROBIAL SOURCE TRACKING STUDY

FOR

SOUTH CYPRESS CREEK

HUC TN 08010211007

MEMPHIS, TN

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INTRODUCTION

Pathogens are the 3rd leading cause of river and stream impairments in the State of Tennessee, after siltation and habitat alteration, thus pathogens are the most common impairments that have a direct effect on human health. Nationwide, pathogen impacts are one of the top three causes of impairments in most states. Although many stream segments are shown in the TN 303(d) list for pathogen impairment, few have had sufficient testing to show that they are actually impaired based on the water quality standard of a geometric mean over 200 cfu/100 ml for 10 samples collected over a 30-day period. The unit “cfu/100ml” is colony forming units per 100 milliliters of sample.

As stated above, the standard for listing waters as impaired in TN is a geometric mean over 200 cfu/100 ml for 10 samples collected over a 30-day period or a one time result of 1000 or greater. The standards vary by state throughout the country with neighboring states that share watersheds sometimes having very different standards. Also, fecal coliform is an indicator species, which indicates the possible presence of organisms that are harmful to humans. Thus, the source of fecal coliform detected by a test is important, since many pathogens are species specific. For example, a result of 1000 in a stream that has been impacted by human waste would tend to be more likely to harbor pathogens that can cause sickness in humans than a stream that had a result of 1000, but where the source was cows.

Most of the streams on the State of TN 303(d) list have, however, exceeded the one-time sample criteria of any one sample result over 1000 cfu/100 ml, whether or not enough sampling has been done to determine if the 30-day geometric mean has been exceeded. The problem with the one time standard is that virtually all streams will exceed this standard at some point. As shown by the samples for this study, which were taken at 5 minute intervals, fecal coliform results can vary widely over a short period of time.

Using the State 303(d) lists as a guide, State and Federal agencies are proceeding with the development and implementation of Total Maximum Daily Loads (TMDLs) with little information about the actual extent of the impairment. For example, according to the information in the TMDL document for the watershed that includes South Cypress Creek (the subject of this project), the Creek was added to the list of impaired streams as shown by the 1996 305(b) Report after only 4 samples were collected over a 3.5 year period. It did not appear to have been listed in the 1994 305 (b) Report, although the 3 samples collected in 1993 and 1994 exceeded the 1000 limit, whereas the 1995 sample did not.

Even worse, there is virtually no information about the source of the fecal coliform detected other than anecdotal reports, possible sources based on studies in other parts of the county, suppositions, and guesses. Sources such as urban wildlife, native animals, migrating birds and the homeless are not given on the TN 303(d) list, although they are proven sources in many locations.

While it is not necessary to know the sources for listing a stream, since listing is caused by violation

of the water quality standard (which can be determined whether or not the source is known), it is necessary to know the source in order to be able to fix a problem that has been identified. Since one of the main purposes of the 303(d) list is to identify impaired streams, so that programs can be enacted to clean them up, it is critical that the sources be accurately identified and the relative contributions (or actual amounts) be quantified as best as possible.

There is no way for the goals of the Clean Water Act (“fishable, swimmable water”) to be realized without source identification, since a program to reduce impacts from an incorrectly identified source will result in no water quality improvements and a waste of resources when the resources could have been better used addressing actual sources. Microbial Source Tracking (MST) studies show promise in being able to identify sources (or at least indicate probable sources), so that appropriate actions can be taken to achieve the water quality goals.

BACKGROUND INFORMATION

Watershed Description

The South Cypress Creek watershed is 14 square miles and is located completely within the City of Memphis. The USGS hydrologic unit code (HUC) is TN08010211007, which puts it within the Nonconnah Creek Hydrologic basin, although it does not join directly with Nonconnah Creek. Both Nonconnah Creek and South Cypress Creek terminate at Lake McKellar. Lake McKellar is actually an inlet of the Mississippi River (a cutoff stream meander), thus, water in Lake McKellar flows in a generally southwesterly direction toward the Mississippi River. The terminus of S. Cypress Creek is downstream of the terminus of Nonconnah Creek. During high river stages on the Mississippi River, water from the River/Lake can back up into the mouth of South Cypress Creek. The sampling for the subject project coincided with low water levels in the Mississippi River.

The water gradient for the mainstem of the Creek is very shallow (approximately 50' elevation drop over a stream length of approximately 18.1 miles), although much of the Creek's original sinuosity has been removed due to urbanization.

Development has generally been greatest in the upstream portions of the watershed as can be seen by the density of the streets, lessening toward the mouth of the Creek. Much of the lower portions of the Creek's watershed are relatively undisturbed forest and flood plains.

Fecal History

As shown by the data extracted from the TMDL, few samples had been analyzed from the watershed up to 1998. Beginning in 2001, in accordance with the State of TN's 5-year watershed cycle, State personnel began sampling monthly at 2 locations along with 6 other sites being sampled 1 to 3 times during the year. State sampling personnel reported a strong sewage-type smell at some locations and sporadic extremely high results, however, no sanitary sewer or other sources could be identified.

Further complicating the issue is the fact that the high results would appear on the same day at sites with no hydraulic connectivity indicating separate sources. Sometimes, sites downstream of sites with high levels would show much lower levels, indicating that the problem was much more complicated than a single source discharge at a single point. Also, there appeared no relation to the high levels and rainfall events or lack of rainfall.

In April of 2002, personnel from the local Environmental Assistance Center (EAC) contacted the City of Memphis regarding the high fecal coliform results. City personnel researched sanitary sewer records to see if there were any correlation to reported sanitary sewer overflows and the sample results, yet no correlation was found.

Therefore, in May of 2002 the City hired a contractor to collect ten samples over a 30-day period

from nine locations, for a total of 90 samples, in the watershed to determine if sources of fecal coliforms to the watershed could be identified geographically. Again, high results would appear on the same day at some sites with no hydraulic connectivity. Sometimes, sites downstream of sites with high levels would show much lower levels. Also, there appeared no relation to the high levels and rainfall events or lack of rainfall. On several of the small tributaries, the results would be very low for most of the samples, with a few high results. The geometric mean of the sample result was near or below 200 for 5 of the sites with the other 4 ranging from 425 to 583. Thus, although there were some results over 30,000, which are violations of the State water quality standard, the geometric mean shows that these were extreme values that are probably not representative of the overall water quality. The fact though that they reoccur and that they occur at a variety of sampling points does indicate that there may be a source that could be identified, at which point, it could be determined whether or not it were possible or prudent to implement measures to eliminate this source.

TDEC conducted additional sampling in June and July of 2002 to collect 10 samples at each of 4 sites within a 30-day period in order to determine if the water quality impact in South Cypress Creek is in excess of the water quality standards. Of the 4 sampling locations, three of which are on the mainstem of the Creek, all showed similar high levels of fecal coliform for most of the sampling events. The geometric mean of the samples ranged from 2998 to 21,258. Note that State personnel also tested for e. coli for which the geometric ranged from 652 to 3281.

TDEC EAC personnel met with representatives of the City of Memphis Sewer Department and the City of Memphis Storm Water Program to discuss their findings on January 7, 2003. At that meeting, the Sewer Department presented a map showing the location of the public sewer lines and the sewer overflow activity in the watershed. Both State and City personnel reviewed the sewer map, but could not find a correlation of sewer overflows to the high levels of fecal coliform and e. coli found in the samples.

Since December of 2002, the City of Memphis has added a site on South Cypress Creek at Riverport Road to its monthly ambient sampling program. The monthly sample from this site is analyzed for e. coli and Enterococcus.

Extensive sampling had been conducted by both the State and the City within a reasonably small watershed, yet the source of the fecal coliform remained elusive. Since the sampling conducted by the State personnel showed a similar lack of geographic focus as to the location of the high sample results and a large variation in the results at the sites, even from one day to the next, the City of Memphis decided to work with the Institute for Environmental Health (IEH) to see if sources could be identified.

SOUTH CYPRESS CREEK PROJECT

Project Elements

The microbial source tracking project for South Cypress Creek was comprised of six basic elements:

- Creek sample collection
- Local lab analysis for fecal coliform
- DNA isolation and analysis
- Scat (source) sample collection
- Scat (source) sample DNA isolation and analysis
- Final report preparation

Tom Lawrence of the City of Memphis and Dr. Mansour Samadpour of the IEH discussed possible sampling strategies ranging from a few samples at each of several sampling sites to collecting all of the samples at one site. In order to be able to properly identify the sources in the watershed and to make sure that the results were as statistically valid as possible, they chose to collect all of the samples at one sampling location, which is where South Cypress Creek passes under the bridge at Riverport Road.

The City of Memphis contracted with Hess Environmental Services (HES) to collect 10 samples at five minute intervals during a total of 12 visits, for a total of 120 samples, to the site over a 1 month period. A HES employee picked up the sample collection bottles and the Chain-of-Custody form from GTW Analytical Services, Inc (GTW). HES Senior Environmental Technician, Jim Reed, collected the samples using proper clean sampling techniques using a bucket lowered from the upstream side of the bridge. The samples were collected in the morning during the work week and Chain-of-Custody procedures were followed.

Once collected, Mr. Reed transported the samples to GTW for analysis for fecal coliform using standard techniques. Once the analyses were complete and the results tabulated, the plates were shipped to overnight to IEH for analysis.

Once shipments were received at IEH, the water samples underwent testing to isolate e. coli bacteria and to provide for genomic (chromosomal) DNA isolation. Using this information and the IEH library, IEH identified likely sources.

The City of Memphis contracted with HES for the collection of scat samples to be used as known sources with which to add to the IEH library of known possible sources for better matching for identification of bacteria sources. Concurrently with the Creek water sample collection, HES personnel collected samples from animals at Shelby Farms Park, the Mid-South Fair Livestock Exhibits, and the Vet Pets Animal Hospital. Additionally, HES worked with Biologist, Dr. Jack Grubaugh of the University of Memphis, to collect samples from three fish species in South Cypress Creek. No e. coli matches with fish fecal samples would be expected, since e.coli grows in warm

blooded animals.

All samples were shipped overnight from HES to IEH.

Once IEH received the scat samples, the same procedures described above for the Creek water samples were followed.

Objective of Project

The objective of this project was to be able to determine possible sources of fecal coliform levels found in South Cypress Creek, as well as to be able to try to quantify the impacts. By identifying the sources of the impacts, the City will work to achieve the goal of the Clean Water Act by addressing the specific sources where possible.

Data Analysis

Extensive review of the data received was conducted in order to determine any patterns in occurrence of fecal coliform from the various possible sources. It is important to remember in this type of project, that the MST results give a general indication of the expected relative importance of the various source categories, not an exact percentage. The number of isolates per plate is not proportional to the total number of colony forming units (cfu) on the plate. For example, there were on average, two isolates from each plate sent to IEH, thus, if the lab recorded a result of 300 cfu for one of the plates and 5000 cfu for another, there would be 2 isolates from each plate. Also, there are a wide variety of the types of coliform in natural waterbodies. IEH conducted ribotyping on e. coli strains from the fecal plates. Two plates which had the same fecal coliform result could have very different amounts of usable colonies from which isolates could be obtained. The issue of varying relative amounts is not addressed by running just the e. coli tests (rather than fecal coliform), since unusable colonies can also exist on those plates.

Since the goal of the analysis was to determine possible source categories for identification and elimination of fecal contamination, where possible, the source results were grouped into five broad categories. The categories used were not based on genetic relationship of the sources, but on occurrence and methods to address them.

The five source categories and the contributors included in the category are as follows:

SOURCE	IDENTIFIED CONTRIBUTORS
Avian	Avian
Human	Human, Raw Sewage
Pets	Canine, Dog, Feline, Horse
Wild Animals	Deer, Opossum, Rabbit, Raccoon, Rodent, Squirrel
Unknown	Unknown

Although the identified contributors have been grouped into source categories for more meaningful analysis, it is important to remember that with all of the sources, there are still many differences, such as differences in the pathways of contamination and in the importance to human health effects.

AVIAN - Avian sources tend to be characterized by very mobile and seasonal sources with little control by human activities, although the building of dams for lakes and diminishing wetlands encourage birds that were once dispersed over a wide area during migrations to concentrate in certain areas. This concentration may lead to higher levels of bacteria than would be found in non-disturbed areas. Thus a solution for this type of bacteria contamination would be efforts to disperse the birds into a wider variety of habitats. Often, when birds are identified as sources of contamination in specific waterbodies, particularly lakes and lagoons, the reaction has been to implement measures to drive them away. While this may help a specific waterbody, it does not solve the problem, since the birds either move on to another location or do not survive.

HUMAN - Human sources identified in this project were classified as “Human” and “Raw Sewage.” Although there can be a wide variety of pathways for human sources, the goal for addressing identified contributors is elimination of the source. For the “Human” contributor, sources could be the homeless (this is important in some parts of the country, but not expected in this watershed), improperly functioning septic tanks, and household sanitary sewer lines that are not connected to the sanitary sewer treatment system. Source removal in this case would involve the identification of the specific point sources and the necessary construction to stop the discharge. Sanitary sewer service is available to the whole area of this watershed, but there are probably several pre-existing structures using septic tanks. Source removal of the homeless contribution to fecal coliform levels, where this is a problem, includes the installation of public toilets and encouraging the use of homeless shelters.

For the “Raw Sewage” contributor, sources are primarily sanitary sewer overflows and improperly maintained private sanitary sewers systems (particularly at apartments). In many areas of the country, combined sewers are a source of bacteria, however, there are no combined sewers in the City of Memphis. Source removal for sanitary sewer overflows involve efforts to reduce inflow and infiltration, perform maintenance and implement programs so that blockages do not occur, and

quickly responding to blockages that do occur. The inflow/infiltration (I/I) rate for the Maxson Wastewater Treatment Plant, which serves this watershed, is very low, with additional flow at the plant seen only in extreme storm events. There is no measurable increase in sanitary sewer overflows in this watershed during rain events. The City of Memphis Sewer Department has a proactive program to identify and repair problem areas in the sanitary sewer system before they lead to stoppages in the lines. For example, there are both City crews and hired contractors that do preventative maintenance cleaning of the sewer lines, particularly in areas where stoppages have occurred in the past. Since many stoppages are caused by grease in the lines, there is a crew that inspects all restaurant grease traps to ensure that they are functioning correctly. Sanitary sewer stoppages are usually fixed within the day that the City is notified of a stoppage. In addition to fixing the stoppage, the responding crews also document the amount of flow being discharged. Citywide, less than 1% of sewage is discharged annually, which is one of the lowest rates in the nation for a large sanitary sewer system. Source removal for private sanitary sewer system discharges involves contacting the owner of the system and requiring that they fix the system to eliminate the discharge. During the sampling period of this project, there were no reported sanitary sewer overflows in the watershed that would have skewed that results.

PETS - Pet sources identified in this project were classified as “Canine,” “Dog,” “Feline,” and “Horse.” Although there can be a wide variety of pathways for these pet sources, the goal for addressing these types of identified contributors is minimization of the source where possible and to change the habits of the owners of pets, so that proper management of the pet wastes is considered an important part of being a responsible pet owner. For the “Canine” contributor, this could also include wild animals, such as coyotes, which are common to this watershed, however, for this study canine was included with the pets. There were only 2 isolates of this type.

While there are 4 very different source pathways for impacts due to “Dogs,” source control can be accomplished in much the same way. The potential primary source pathways from dogs are from loose dogs in the watershed, dog owners not picking up and properly disposing of waste during walks, dog owners leaving waste on the ground on their property where bacteria can wash off, and owners who pick up the waste from their property, but dispose of it in a storm drain. These types of problems can be most effectively managed by public education programs to remind owners that responsible pet ownership includes proper disposal of dog waste.

In addition to cats, “Feline” sources can include native wild cats, such as bobcats. Outside of native wild cats, this issue would be caused primarily by house cats that are let out at night to wander around and stray domestic cats. Programs to encourage keeping cats indoors and spaying and neutering would be cost effective approaches for this type of source. “Horse” contributions would depend on the relatively density of the horses in the area where they are fenced. Generally in areas where the “Horse” contribution is found to be a problem, the sources would have to be addressed on an individual basis, such as minimizing runoff from these areas. For the South Cypress watershed, the horse contribution does not appear to be a problem, since there were only two isolates of this type.

WILD ANIMALS - Wild Animals sources identified in this project were classified as “Deer”,

“Opossum”, “Rabbit”, “Raccoon”, “Rodent”, and “Squirrel.” This was the catch-all category for sources that were generally outside of human control (other than Avian and some of the Pets). Aside from Raccoon and Rodent, the other sources in this category had very few isolates (three or fewer) identified for each of them. The contrast between the four with low occurrence (such as squirrels) and the two with high occurrence (such as raccoons) is interesting. Although the number is not known, there are probably high numbers of both squirrels and raccoons in the watershed. One of the reasons for the high occurrence of isolates for raccoons (38) versus squirrels (1) could be that anecdotal data suggests that raccoons tend to like concrete storm drains and to live in them and to use them for travel, whereas squirrels do not seem to frequent storm drains. Also, there was a high percentage of rodent isolates, which may include some squirrel, as well as rats and other common rodents.

UNKNOWN - Unknown sources indicated in this project as those for which no isolate match could be found. The IEH library has many thousand isolates used for identification. Due to the large size of the library, it is unlikely that these were common isolates from a type of source that was missed. It is more likely that they are rare occurrences from the sources named by other isolates in the study. Thus, the general distribution given in the study with the available identified isolates is expected to be similar, even if it were possible to identify the ones listed as unknown.

Results

Since the results cannot give specific amounts of bacteria contributed by each source, but can give relative amounts, analysis by inspection of graphs and tables gives the most useful results. Inspection of the graphs and tables show the following:

Figure 1 provides a table of the fecal coliform results for all of the samples by the time of day that the samples were collected. There were no apparent time of day variations within the time period sampled (approximately 2 hours). Also, all of the samples collected on each day were fairly consistent, except on 8/19/02 where moderately high levels were measured in 8 of the samples, but the remaining 2 were <10, and on 9/19/02 where all of the samples were TNTC (too numerous to count), except one which was NC (no colonies found).

Figure 2 shows the total number of matches by each specific source. Inspection of this graph shows that avian, human, raccoon, rodent and unknown are the 5 most common and occur at least twice as often as the next most common occurrence. Note that all of the various types of pets were much lower.

Figure 3 graphs the occurrences for all of the identified sources versus the fecal coliform result for the sample reported by the lab. While there are quite a bit of small variations, five identified sources are evident. The Avian source is found in many isolates in both the low end of the graph (indicating many diffuse sources) and at the high end of the chart (TNTC) indicating direct discharge into the creek. A similar distribution is seen for both the racoon and rodent identified sources (which are later grouped into one source group for later data interpretation). Also, human and sewage sources are low for all of the fecal result ranges, except for the “TNTC” category, where they both register

higher, (although still much lower than avian or raccoon). This type of distribution would indicate that should human and sewage identified sources occur, most of the time there is direct discharge to the Creek, however they are probably rare, since only two of the 12 events had TNTC levels.

Figure 4 is a pie chart showing the relative occurrence of the five major source groups and which identified sources were included in each source group for the data interpretation. Note that no single group dominated the South Cypress Creek study as the “cause” of the fecal coliform levels found, although wild animal sources followed by avian were by far the most often seen.

Figures 5 and 6 provide a summary of the total number of isolates for each source, sorted alphabetically and by frequency of occurrence.

Figure 7 shows the number of isolates per source category versus fecal results (in 4 fecal results groupings). Figures 8-12 show the percent of each fecal grouping for each of the five source groupings. Based on these graphs, several trends are apparent.

The **Avian** category had its highest numbers of isolates in the “0-1000” and “TNTC” categories with lower numbers in between, indicating that there may be both diffuse sources of Avian fecal coliform (such as deposited areas that are washed into the creek at a slow rate), as well as direct discharges into the creek, providing the high numbers. In the highest fecal results category, the avian contribution was nearly 40% of the total (figure 8).

The **Human** source group was fairly consistent at 10 - 15 isolates across all of the fecal groupings (figure 7), however, in the percentages (figure 9), the percentage of human impact tended to increase as the fecal results were higher, indicating that, although the total human impact was fairly low, it seemed to be more likely to be responsible for high fecal results (“>4000” and “TNTC”) than for lower results, although the human contribution doesn’t exceed 25% for any of the fecal results groupings.

The **Pets** source group had the 3rd lowest number of isolates in the lowest fecal grouping category and the lowest in the remaining 3 groupings. In the percentage graph (figure 10), the percentage of pet isolates to the total number of isolates went down consistently as the fecal results climbed, which would be consistent with pets having no direct access to storm drains (as far as for depositing fecal coliforms). Thus, pet contributions may be more related to storm water runoff, rather than would be seen with the other major source types which may be related to direct contact with the creek water.

For sources attributed to **Wild Animals**, the number of isolates was higher than all of the other sources in all fecal result groups, except for the “TNTC” group, where it was second to Avian. Across all fecal categories, the wild animals contribution ran from just under 30% to over 40% (figure 11).

The **Unknown** source group, was generally lower than the other groups indicating that lack of identification of these isolates is probably not affecting the usefulness of the data set, since the total number of identified isolates far exceeds the number of unknown results.

Also, the unknown results were not the majority in any of the categories, having less than 20% in all categories.

Figure 13 shows the relative percent of occurrences for each of the source groups for each of the fecal result groupings. Figures 14 - 17 show the percent of each of the five source groupings divided among the four fecal results groupings. By comparison, it appears that the avian contribution generally tends to increase as the fecal result increases, while there is a general reduction in the pet and wild animal contribution. The human contribution remains relatively consistent (though slightly higher in the middle groupings), indicating the possibility of more than one source. Figure 20 shows the relative percent of occurrences (similar to figure 13), but with the unknown results omitted.

The following figures, figures 18 and 19, compare the relative percent of occurrence per day for the five source groupings, with figure 19 omitting the unknown category. The top row of the chart shows the average over the course of the project. It is important to note that, within reasonable variations, the percentages were relatively consistent with the averages for all of the sampling events. There were no days that seemed to skew the data (such as one day having a high percentage for a source category that was otherwise low all of the other days). Looking at figure 19, some interesting observations are the following:

- Except for one day, when no Avian sources were seen, Avian sources were usually nearly 20% to 50% of the total.
- No human sources were seen in two sample events, but were otherwise in about 10% to 40% of the isolates for each day.
- Pet contributions seemed to have the most variability, with two days having none and two days with 30% or more. There were several days when pet isolates were detected, yet were less than 10%. This type of distribution would tend to indicate more diffuse sources as stated above.
- Wild Animal sources were present in all of the sampling event in significant numbers. On 4 of the 12 sampling events, wild animals made up 50% to over 60% of the isolates. Wild animals were over 20% for all samples, except for the first sampling event.
- On one day (9/23/02), only two source groups were indicated, yet both of the source groupings noted (avian and wild animals) were those that had been high in previous sampling events.

Additional Observations

In addition to known source samples provided by the City to IEH for ribotyping for land and bird animals, the City provided scat samples for three common fish species that were collected from South Cypress Creek. None of the isolates matched the fish species, indicating that fish fecal matter does not contribute to the fecal coliform levels found in the Creek.

Also, there were no bovine identified sources on South Cypress Creek. This is consistent with observations in the watershed, where no bovines (cattle) have been observed.

Summary of Results

In summary, the results of this project showed the following:

1. The primary sources of fecal contributions to the creek were avian and wild animal sources. The percent of contribution of these sources may actually be more than estimated, since “canine” and “feline” sources were grouped with Pets, but may include wild canine and feline sources instead of domesticated animals. The wild animal levels may be elevated in urban streams versus natural areas due to the nature of urban wildlife, which may prefer the storm drain areas for habitat and the storm drain areas may be the only habitat in some parts of the watershed, since the land on either side may be developed. Avian sources of fecal coliform may be attracted to manmade ponds and drains where there is consistent water flow and since their preferred habitat may not exist.
2. The fact that several isolate sources were unknown did not appear to skew the results, since there appeared to be fairly evenly distributed both temporally (each day of sampling had a few unknown samples) and over the fecal coliform results (each results group had a few unknown samples). It is possible that the unknown samples could represent another unidentified source, rather than being distributed among the known sources, but if so, this source is a minor contributor to the fecal coliform contamination found in the creek (about the same level as pets), even if all of the unknown isolates were the same source, which is unlikely.
3. The City has been conducting an aggressive water pollution public education program for several years, including information about the need for pet owners to pick up after their dogs. Thus, while there is no historical data about the contribution of pet waste to the fecal coliform levels in the creek, the results of this study show that the impact is currently very low.
4. The Human source category (comprised of human and raw sewage identified sources) was a relatively small overall contributor to the identified sources in the creek, but may be a contributing source (after avian and wild animals) to the episodic TNTC levels measured. The City has an aggressive sanitary sewer inspection and maintenance program, as well as quick turn around for repairing reported stoppages, thus, the public sanitary sewer system does not appear to be a significant source. Additional research may yield possible source locations, including improperly functioning septic systems and unconnected private sanitary sewers.

Next Steps

The City of Memphis is proceeding with an MST study in the Nonconnah Creek basin to determine likely sources of fecal coliform contamination found in Nonconnah Creek, which borders South Cypress Creek to the north and is included in the same USGS HUC watershed.

The City will continue to implement storm water public education, sampling and enforcement measures and sanitary sewer inspection, maintenance and response functions to ensure that discharges from areas under the city’s control are minimized. Also, efforts to establish greenways

and to preserve habitat will help to provide habitat for wildlife outside of the storm drainage system.

Funding

This project was funded by the City of Memphis Department of Public Works, Environmental Engineering Service Center and a Grant from the Tennessee Department of Environment and Conservation.

Approximate costs were the following:

PROJECT PHASE	COST
Sample Collection	\$2,700
Sample Analysis for Fecal Coliform	\$1,620
Scat Sampling	\$4,000
Ribotyping (creek and scat samples)	\$18,000
Project Management and Final Report	\$5,000
Total Approximate Cost	\$31,320

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